# TELESCOPE SELECTION BY COMPUTER
## the LOGICAL CHOICE

By: P. Bingham

This article is for any TS computerist who is contemplating the purchase of a telescope. It was written as a result of months of research and should, I hope, aid the would-be telescope owner in making the best choice.

With Halley's Comet on the way around Christmas time, the scope dealers will surely inundate us with fancy and impressive ads. What is worthwhile and what is not? Which scope would be best? Such answers depend on what your viewing interests are and how much money you have to spend. The money part is up to you and your budget. What your needs are can be sorted out by you and in part by your computer.

To start, I have included a list of features and specifications to look for in a scope. This is a consensus of many scope users:

1. The largest aperture (light-gathering lens or mirror) that you can afford but can still store and haul easily.
2. A focal ratio of greater than f/4.
3. Quality optics. Look for a rating of 1/8th wave or more.
4. A good finderscope with cross hairs and mounted so as to be adjustable. 6x30mm or larger is nice.
5. A rack and pinion focuser which takes 1¼" eyepieces min.
6. A sturdy mount. Wood or metal is okay. Equatorial type mounts are more expensive but allow easier tracking of objects in the sky (which is constantly in motion). Consider them seriously in spite of cost or choose a scope which can be mounted as such later.
7. Setting circles help locate faint objects from star chart information or figures from ASTRONOMER program (reviewed this issue).
8. Slow motion controls (usually knobs at the end of cables) allow manual tracking.
9. A tracking motor drive or capacity to add one later. A necessity if you want to take pictures.

Aside from these items, the rest of the pitch you will get in a showroom or a brochure is gloss and of little substance. Often what you really want to know is obscured or not mentioned at all. (This is no different from shopping for hardware or software!) To find this information will take a little digging. Items 4 through 9 are usually mentioned or pictured and simple study will bring these to light. Items 1 through 3 being the most important

are also the most elusive. The balance of this piece is devoted to finding and studying these in depth with your computer. We need no expertise here, the computer will handle things nicely. Entries requiring numbers by the program will accept inches or millimeters and compensate for each.

Type in the program listing #1 (#1a for TS 1000/1500) just as it appears and RUN. You will be asked for the scope's name, etc. Hit ENTER if this is unimportant for a print-out later. Next you will be asked the size of the aperture. It is sometimes referred to as the objective, primary mirror or clear aperture depending on the type of scope.

Next the program asks for the size of the secondary. In scopes with no mirrors (refractors have none) there is no secondary so just input Ø and move on. In a mirror system this is what bounces the light to the eyepiece for viewing. The secondary is also known as the obstruction or the elliptical mirror. If its size cannot be determined then enter Ø, the program will still function.

The final value needed by the program is the focal ratio or the f/ value as it is commonly written. This term is familiar to anyone in photography. It is always written as f/5, f/4.5, f/15 and so on. If the value cannot be found then input Ø. The program will then ask you for the focal length or tube length. From this the program can calculate the f/ value. Try to find the focal length listed somewhere, as this is most accurate. If it, too, is not available then enter the telescope's tube length listed or physically measured with a tape. (Note--this will prove sufficient for all but the so-called "Catadioptric" or "folded light path" designs. The popular Cassegrains are among these. Such designs allow for a deceptively short and stout tube. Manufacturers of these normally list the f/ values and true focal length since these are among their best features.)

With these numbers the computer will now crunch momentarily and then fill the screen with "everything you want to know and more". See fig A, B or C as a sample. You may at this point make a print-out if you wish.

Now comes the fun part...checking the computer's results with the claims of the manufacturer or salesman. We will follow the examples of fig A, B and C. Notice the first item listed is the aperture we entered shown now in inches and millimeters. The table in fig D is a guide to what is required as a minimum for the study of a given subject by aperture size. Look over this carefully before buying a scope. Sizes listed in fig D are based on optimum conditions for viewing.

The information we input regarding the secondary is shown next. (If you could not find this originally then the two figures listed after "Light-grasp" will be incorrect.) Light-grasp is a function of the aperture. It is listed in relationship to the dark-adapted human eye.

"Obstruction" is next. This is simply the size of the secondary compared with the aperture. If high magnification is required by you, say for lunar or planetary detail, a number closer to 15% is ideal. The larger the percentage, the more incoming light is obstructed, causing dimming and loss in image clarity. Our examples are all well above this. If broad nebulae or comet sweeping is on your agenda then the opposite would be true. A larger secondary is also more forgiving if slightly out of alignment. Many scopes are between 25% to 30%. This is passable for most work.

The "Free Objective Area" on the next line shows the actual unobstructed surface area in relation to the human eye. Notice in fig A & B that the apertures are very close but their free areas are more different. This is due to obstruction.

Magnitude range shows the limits of faint star light the telescope should be capable of picking up. The "minimum" is the limit an optically sound scope should be able to reach under dark, clear skies. The "maximum"is a limit which on rare occasion might be attained. A manufacturer's claim should fall between the two. These magnitude figures can further aid us in choosing a scope. By looking through astronomy references, say at the library, you can identify items of viewing interest along with their magnitudes. Now keep in mind that the magnitude value is the point at which the object is first barely visible. If the scope's values continually meet and do not exceed these then go with a scope of larger aperture.

The next item, tube length may not seem important. This tells us the shear size of the scope. How much room do you have to store it? If you want to take it on outings will there be room in your vehicle for the scope AND your passengers? The scope in fig A is designed with backpacking in mind. Its counterpart in fig B would be too long. Here also is where the designs which "fold" their light paths come in. This does improve portability but little else. The number shown for those would be the true length if not "folded".

Unless you were asked to supply it, the next value (focal length) has been calculated for you. Check this with the manufacturer's number if they list one. The focal ratio is given next and will either appear as it was input or as has been calculated. This value will reveal much about a scope's use. Anything under f/4 is too short and may cause optical deficiencies. Anything below f/5.5 is refered to as "rich field" type. It is well suited for seeing faint objects but not for highest magnifications of planets and such. A scope of f/8 or more is better for those. The f/6 is a good compromise.

The computer has now analyzed the scope in question and calculated recommended magnifications and the eyepiece sizes required. Eyepiece size alone is what determines magnification or power. Every scope has limits of useful magnification. Going above or below the values given by the computer only distorts the image and never improves it. Avoid scopes which advertise powers beyond these limits!

(NOTE--In some cases the manufacturer will list powers obtained with a Barlow. This is like a doubler in photography and most are X2. This effectively doubles the focal length. If this be the case, you can rerun the program and input Ø when asked for the f/ value. Then enter double the focal length when asked. This will give you the limits with a Barlow. Like a doubler, some loss in image quality results from a Barlow's use.)

In fig A & B the eyepieces recommended for Max are 3mm and 2mm. Since no good eyepieces below 4mm are available, the use of a X2 Barlow with a 6mm and 4mm eyepiece respectively would be needed. Many eyepiece types are available in most sizes. "Orthoscopics" may be the best all-around type, but others are even better suited to specific viewing interests. Avoid "Huygenian" and "Ramsden" types as they are cheap and leave you with headaches if used too long. Scopes furnished with such should be suspect.

The last two values produced by our trusty program concern resolution. Many double stars ar groups of stars (globular clusters) may only appear as one fuzzy object unless the resolution is good. If a scope's value of optical quality is not given directly (1/8th wave, 1/10th wave, etc.) then we must look to other signs. Resolution is such a sign. To illustrate lets consider NASA's Hubble space telescope due for shuttle launch in 1986. It is the most optically perfect scope ever produced. It can resolve or "split" two headlights on a car in New York from Los Angeles. Now that is resolution!

The standard formula for resolution produces "Dawe's Limit". A scope of long focal length should be able to equal or even be less than this theoretical limit. The probable resolution listed last takes into account the inherent design of the scope in question. It may well show as lower or higher than Dawe's limit. (NOTE--"arc sec" is a common term used when referring to resolution. The full moon spans some 1800 arc seconds.)

PARTING SHOTS

One cannot be too careful when searching for a telescope. The shiniest scopes can be the most worthless and the homely the best money can buy. By using this program and your common sense you will quickly expose the worthless ones.

For more information I would consult the latest copy of "Astronomy" or "Sky & Telescope" magazines. Sift through the ads and send for catalogs. Do not be afraid to send $1 or $2 for a catalog. Many are packed with pictures and information. Among the thirty places I contacted, three stand out: Ad-libs Astronomics, Chicago Optical and University Optics. But many others were good, too.

The last piece of advice: Do not be afraid to <u>wait</u> for the right scope. That is right! With Halley's Comet coming many makers of good scopes are backlogged with orders like never before. A scope I ordered in June will not be arriving until October. If its what you need and can afford then buy it and enjoy. I will leave the hunting and dreaming to you and your TS computer.

pb

```
.....................................
APERTURE: 4.25 inches    108mm
Secondary: 1.3 inches    33mm
Light-grasp: 226 X eye
Obstruction: 30.5%
Free Objective Area= 165 X eye
Magnitude Range:    min 11.9
                    max 13
Unfolded Tube Length: 2.48 ft
Focal length: 756mm
Focal Ratio: f/7
Magnification Limits:
  Max: 220X     eyepiece: 3mm
  Avg: 100X     eyepiece: 7mm
  Min: 14X      eyepiece: 54mm
Dawes' Limit: 1.072 Arc sec
Resolution Prob: 1.343 Arc sec

For: Chicago Optical 710     $209
.....................................
```

fig A

```
.....................................
APERTURE: 4.13 inches    105mm
Secondary: 1.5 inches    38mm
Light-grasp: 213 X eye
Obstruction: 36.1%
Free Objective Area= 149 X eye
Magnitude Range:    min 11.8
                    max 12.9
Unfolded Tube Length: 1.44 ft
Focal length: 440mm
Focal Ratio: f/4.2
Magnification Limits:
  Max: 220X     eyepiece: 2mm
  Avg: 100X     eyepiece: 4mm
  Min: 13X      eyepiece: 33mm
Dawes' Limit: 1.103 Arc sec
Resolution Prob: 1.518 Arc sec

For: Edmund ASTROSCAN 2001   $229
.....................................
```

fig B

# LISTING 1

```
  1 REM   SCOPE
  5 LET g=390: LET A1=0: LET S1
=0
 10 PRINT AT 20,0;"Name & Model
 of scope:": INPUT N$: CLS
 15 INPUT "size of aperture? ";
A: GO SUB 300
 20 IF A1=0 THEN LET A1=(INT (1
00*(A/25.4)))/100
 25 INPUT "size of secondary mi
rror? ";S: GO SUB 300
 30 IF S1=0 THEN LET S1=(INT (1
00*(S/25.4)))/100
 35 INPUT "focal ratio? ";R: LE
T F=INT (.5+(A*R)): IF R<>0 THEN
 GO TO 50
 40 INPUT "focal length OR tube
 length? ";F: GO SUB 300
 50 REM   light-grasp
 55 LET LG=INT ((A1*3.54)↑2)
 60 LET L=INT (((A/2)↑2*PI)-((
S/2)↑2*PI))/50.264)
 70 REM   % obstruction
 80 LET P=(INT (1000*(S/A)))/10
 90 REM     magnitude
100 LET min=(INT (10*(8.8+5*LN
A1*.434)))/10
110 LET max=(INT (10*(9.9+5*LN
A1*.434)))/10
120 REM  tube/focal len & f/no.
130 LET T=(INT (100*((F/25.4)/1
2)))/100
140 LET FN=(INT (.5+(10*(F/A)))
)/10
150 REM  magnification
160 LET PL=INT A1*55
170 LET PM=INT A1*25
180 LET PS=INT (.5+(A1*3.2))
190 LET EL=INT (F/PL)
200 LET EM=INT (F/PM)
210 LET ES=INT (F/PS)
220 REM   resolution
225 LET DL=(INT (1000*4.56/(A/2
5.4)))/1000
230 LET RE=(INT (1000*(((178/FN
)-(FN/10+4))*FN)/A))/1000
235 FOR i=0 TO 31: PRINT AT 0,i
;CHR$ 34;AT 19,i;CHR$ 34: NEXT i
240 PRINT AT 1,0;"APERTURE: ";A
1;" inches";TAB 24;A;"mm": PRINT
"Secondary: ";S1;" inches";TAB
24;S;"mm"
245 PRINT "Light-grasp: ";LG;"
X eye": PRINT "Obstruction: ";P;
"%"
250 PRINT "Free Objective Area=
";L;" X eye"
255 PRINT "Magnitude Range:";TA
B 19;"min ";min: PRINT TAB 19;"m
ax ";max
260 PRINT "Unfolded Tube Length
: ";T;" ft ": PRINT "Focal lengt
h: ";F;"mm": PRINT "Focal Ratio:
 f/";FN
265 PRINT "Magnification Limits
:": PRINT TAB 2;"Max: ";PL;"X";T
AB 15;"eyepiece: ";EL;"mm"
270 PRINT TAB 2;"Avg: ";PM;"X";
TAB 15;"eyepiece: ";EM;"mm"
275 PRINT TAB 2;"Min: ";PS;"X";
TAB 15;"eyepiece: ";ES;"mm"
280 PRINT "Dawes' Limit: ";DL;"
Arc sec": PRINT "Resolution Pro
b: ";RE;" Arc sec"
285 PRINT AT 18,0;"For: ";N$
290 INPUT "Copy? Y/N ";A$: IF a
$<>"n" THEN COPY
294 STOP
295 SAVE "SCOPE"
300 LET g=g+10: INPUT "was last
 value in inches? ";A$: IF A$<>"
n" THEN GO TO g
310 RETURN
400 LET A1=A: LET A=INT (.5+(A*
25.4)): RETURN
410 LET S1=S: LET S=INT (.5+(S*
25.4)): RETURN
420 LET F=INT (.5+(F*25.4)): RE
TURN
```

# LISTING 1a

```
""""""""""""""""""""""""""""""""""""""""
APERTURE: 10 INCHES      254MM
SECONDARY: 2.6 INCHES    66MM
LIGHT-GRASP: 1253 X EYE
OBSTRUCTION: 25.9 PERCENT
FREE OBJECTIVE AREA= 940 X EYE
MAGNITUDE RANGE:    MIN 13.7
                    MAX 14.8
UNFOLDED TUBE LENGTH: 3.75 FT
FOCAL LENGTH: 1143MM
FOCAL RATIO: F/4.5
MAGNIFICATION LIMITS:
  MAX: 550X     EYEPIECE: 2MM
  AVG: 250X     EYEPIECE: 4MM
  MIN: 32X      EYEPIECE: 35MM
DAWES  LIMIT: 0.456 ARC SEC
RESOLUTION PROB: 0.621 ARC SEC

MEADE DS-10              $999
""""""""""""""""""""""""""""""""""""""""
```

fig C

```
    1 REM   SCOPE (FOR TS1000)
    5 LET G=390
    6 LET A1=0
    7 LET S1=0
   10 PRINT "NAME AND MODEL OF SC
OPE:"
   11 INPUT N$
   12 CLS
   15 PRINT "SIZE OF APERTURE"
   16 INPUT A
   17 GO SUB 300
   18 CLS
   20 IF A1=0 THEN LET A1=(INT (1
00*(A/25.4)))/100
   25 PRINT "SIZE OF SECONDARY MI
RROR?"
   26 INPUT S
   27 GO SUB 300
   28 CLS
   30 IF S1=0 THEN LET S1=(INT (1
00*(S/25.4)))/100
   35 PRINT "FOCAL RATIO?"
   36 INPUT R
   37 LET F=INT (.5+(A*R))
   38 CLS
   39 IF R<>0 THEN GO TO 50
   40 PRINT "FOCAL LENGTH OR TUBE
 LENGTH?"
   41 INPUT F
   42 GO SUB 300
   50 REM   LIGHT-GRASP
   55 LET LG=INT ((A1*3.54)* 2)
   60 LET L=INT ((((A/2)* 2*PI)-(
(S/2)* 2*PI))/50.264)
   70 REM  PERCENT OBSTRUCTION
   80 LET P=(INT (1000*(S/A)))/10
   90 REM   MAGNITUDE
  100 LET MIN=(INT (10*(8.8+5*LN
A1*.434)))/10
  110 LET MAX=(INT (10*(9.9+5*LN
A1*.434)))/10
  120 REM TUBE/FOCAL LEN AND F/NO
  130 LET T=(INT (100*((F/25.4)/1
2)))/100
  140 LET FN=(INT (.5+(10*(F/A)))
)/10
  150 REM MAGNIFICATION
  160 LET PL=INT A1*55
  170 LET PM=INT A1*25
  180 LET PS=INT (.5+(A1*3.2))
  190 LET EL=INT (F/PL)
  200 LET EM=INT (F/PM)
  210 LET ES=INT (F/PS)
  220 REM   RESOLUTION
  225 LET DL=(INT (1000*4.56/(A/2
5.4)))/1000
  230 LET RE=(INT (1000*(((178/FN
)-(FN/10+4))*FN)/A))/1000
  235 FOR I=0 TO 31
  236 PRINT AT 0,I;CHR$ 11;AT 19,
I;CHR$ 11
  237 NEXT I
  240 PRINT AT 1,0;"APERTURE: ";A
1;" INCHES";TAB 24;A;"MM"
  242 PRINT "SECONDARY: ";S1;" IN
CHES";TAB 24;S;"MM"
  245 PRINT "LIGHT-GRASP: ";LG;"
X EYE"
  246 PRINT "OBSTRUCTION: ";P;" P
ERCENT"
  250 PRINT "FREE OBJECTIVE AREA=
 ";L;" X EYE"
  255 PRINT "MAGNITUDE RANGE:";TA
B 19;"MIN ";MIN: PRINT TAB 19;"M
AX ";MAX
  260 PRINT "UNFOLDED TUBE LENGTH
: ";T;" FT"
  261 PRINT "FOCAL LENGTH: ";F;"M
M"
  262 PRINT "FOCAL RATIO: F/";FN
  265 PRINT "MAGNIFICATION LIMITS
:"
  266 PRINT TAB 2;"MAX: ";PL;"X";
TAB 15;"EYEPIECE: ";EL;"MM"
  270 PRINT TAB 2;"AVG: ";PM;"X";
TAB 15;"EYEPIECE: ";EM;"MM"
  275 PRINT TAB 2;"MIN: ";PS;"X";
TAB 15;"EYEPIECE: ";ES;"MM"
  280 PRINT "DAWES  LIMIT: ";DL;"
 ARC SEC"
  281 PRINT "RESOLUTION PROB: ";R
E;" ARC SEC"
  282 PRINT AT 18,0;N$
  285 PRINT AT 21,0;"COPY?"
  286 INPUT A$
  287 PRINT AT 21,0;"      "
  288 IF A$<>"N" THEN COPY
  290 STOP
  300 LET G=G+10
  301 CLS
  302 PRINT "WAS LAST VALUE IN IN
CHES?"
  303 INPUT A$
  304 IF A$<>"N" THEN GO TO G
  305 CLS
  310 RETURN
  400 LET A1=A
  401 LET A=INT (.5+(A*25.4))
  402 RETURN
  410 LET S1=S
  411 LET S=INT (.5+(S*25.4))
  412 RETURN
  420 LET F=INT (.5+(F*25.4))
  421 RETURN
```

| OBJECT | MINIMUM | COMMENTS |
|---|---|---|
| Mercury | 6" | Needed to ever see any detail (12" best). |
| Venus | most any | This cloudy neighbor is best seen with deep blue or violet filter attached. |
| Mars | 3" | Poles first visible. 6" for serious view. |
| Jupiter | 3" | Cloud bands & four moons visible. 12" picks up detail on largest moon. |
| Saturn | 4" | First good view of rings. 6" better. |
| Uranus | 8" | Tiny green disk. 14" sees a moon or two. |
| Neptune | 6" | Minute disk. One moon in 10" |
| Pluto | 10" | Visible as "star" only. Rare in 8" |
| Planetary Nebulae | 4" | Allows first enjoyable look. |
| Globular Clusters | 10" | Most seen too fuzzy, too faint in less. |
| Galaxies | 6" | Many are revealed first at this aperture. |

fig D